Beyond Crystallography: Atomic Resolution Electron Tomography

Jianwei (John) Miao
Department of Physics & Astronomy and California NanoSystems Institute,
University of California, Los Angeles, USA
Email: miao@physics.ucla.edu

Visualizing the arrangement of atoms has played an important role in the evolution of modern science and technology. Crystallography has long been used to reveal globally averaged 3D atomic structures. Scanning probe microscopes can determine surface structures at atomic level. Electron microscopes can routinely resolve atoms in 2D projections of 3D crystalline samples. In this talk, I will present a general method for 3D determination of *local* structures at atomic resolution. By combining scanning transmission electron microscopy with a novel data acquisition and 3D image reconstruction method, known as equal slope tomography (EST), we achieved electron tomography of a ~10 nm Au nanoparticle at 2.4 Å resolution and identified several major grains in three dimensions (1). We also observed nearly all the atoms in a Pt nanoparticle and imaged, for the first time, the 3D core structure of edge and screw dislocations at atomic resolution (2). More recently, we determined of the 3D coordinates of thousands of individual atoms and a point defect in a tungsten needle sample with a precision of ~19 picometer, where the crystallinity of the sample was not assumed. From the coordinates of these individual atoms, we measured the atomic displacement field and the full strain tensor with a 3D resolution of 1 nm and a precision of 10^{-3} (3). We expect this general atomic resolution electron tomography method to find broad applications in solid state physics, chemistry, materials sciences, nanoscience and biology.

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